Appendix F

Laboratory Evaluations of Power System Transducers

This appendix relates to Chapter 6, §6.4.

Figures F-1 through F-5 are representative of transducer response tests performed by the US Bureau of Reclamation (USBR) under the Wide-Area Measurement Systems (WAMS) project. All of the transducers examined have analog inputs and outputs. This does not necessarily imply, however, that their internal logic is analog. Signal processing for several of these transducers is primarily digital and, from other points of view, are classified as digital.

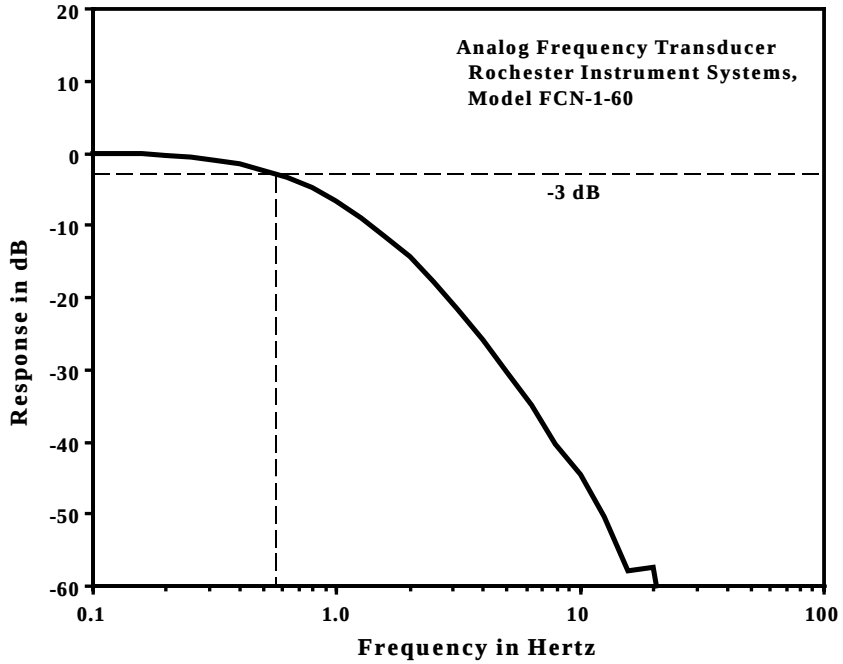

Fig. F-1. Measured frequency response of a Rochester Instruments Systems frequency transducer.

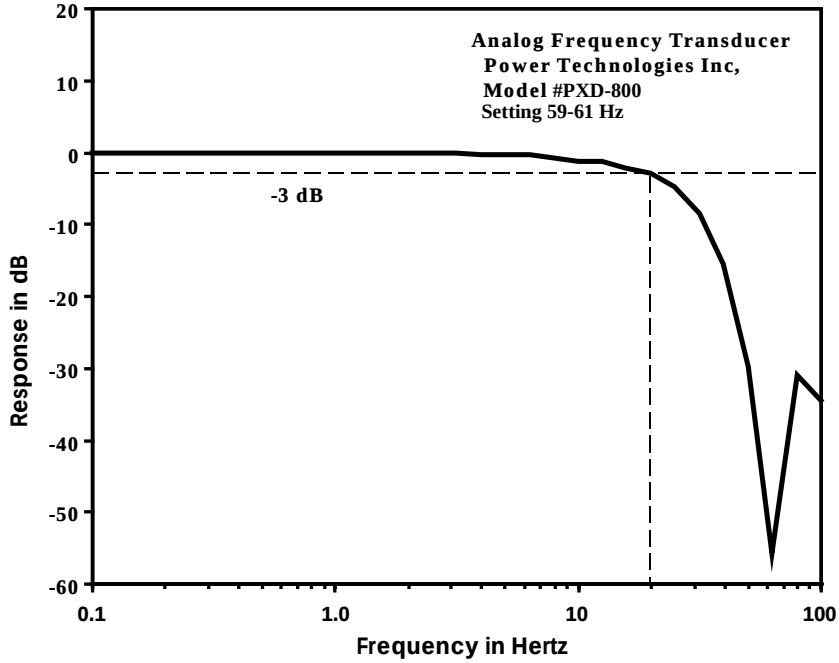

Fig. F-2. Measured frequency response of a PTI frequency transducer.

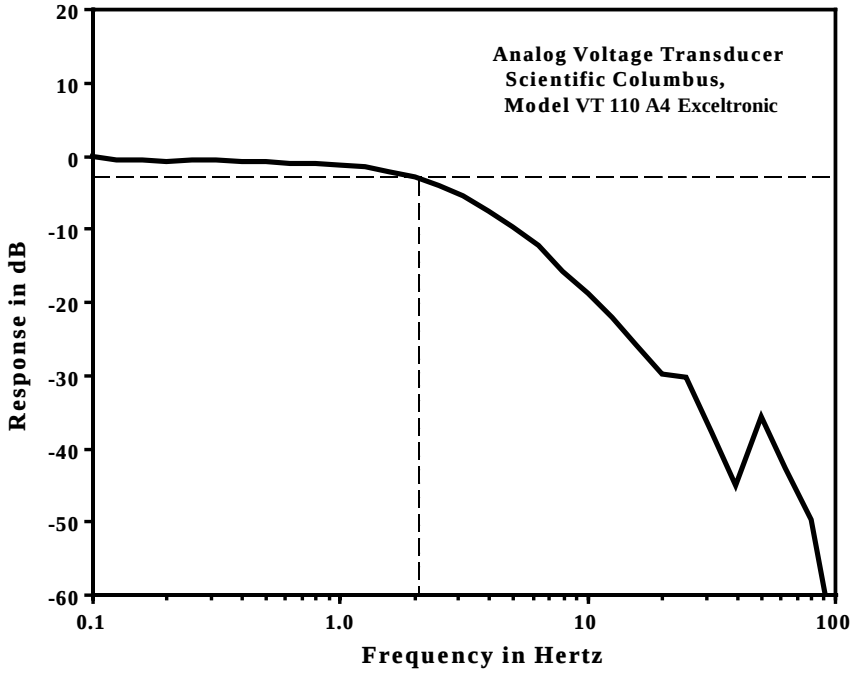

Fig. F-3. Measured frequency response of a Scientific Columbus voltage transducer.

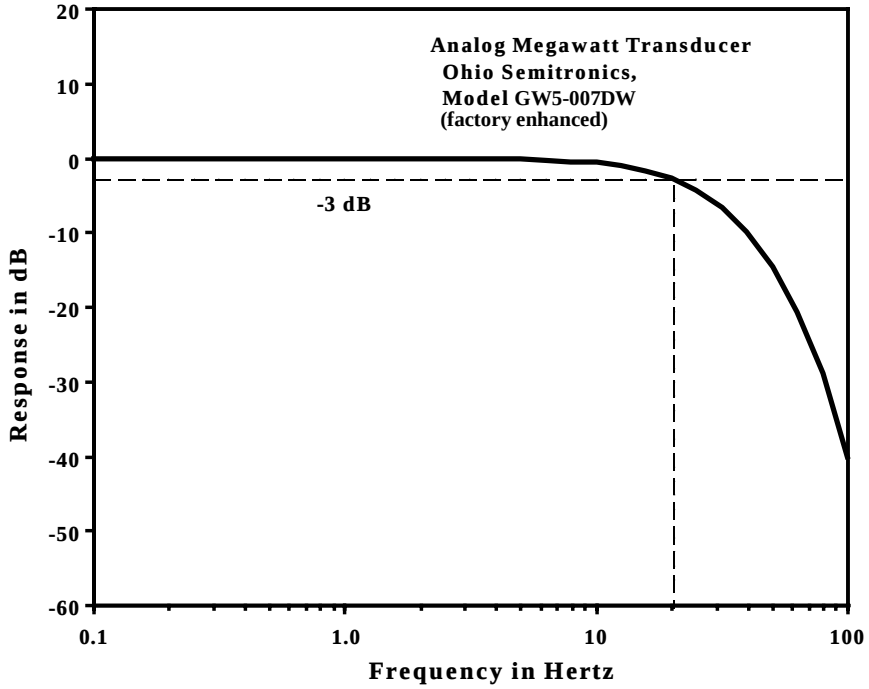

Fig. F-4. Measured frequency response of an Ohio Semitronics watt transducer.

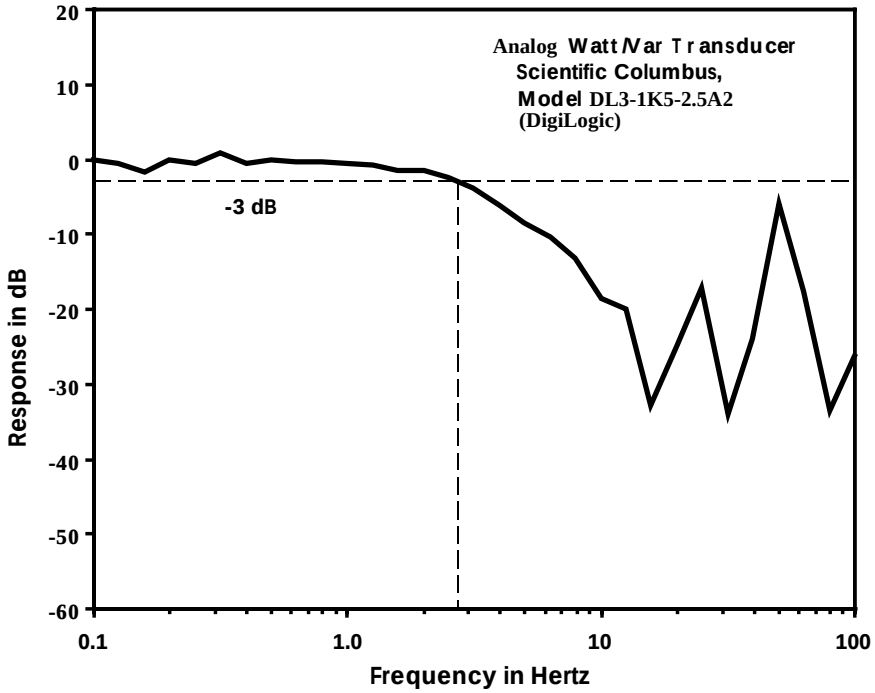

Fig. F-5. Measured frequency response of a Scientific Columbus watt/var transducer.

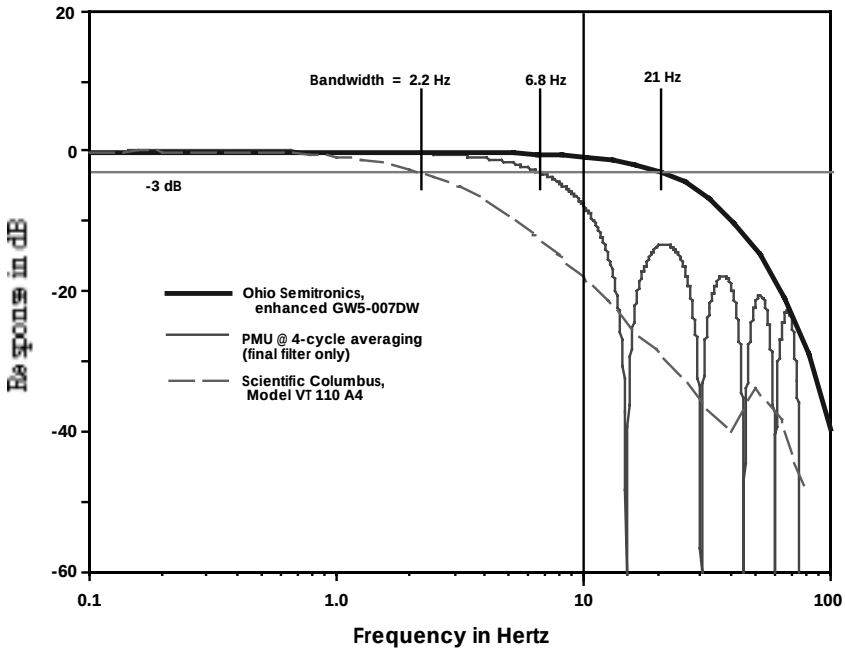

Fig. F-6. Macrodyne phasor measurement unit response versus typical analog transducers.

Each figure shows gain as a function of frequency, with a vertical dashed line indicating the -3 dB bandwidth. The bandwidth values range from a low of 0.6 Hz (in Figure F-1) to a high of 20 Hz (in Figures F-2 and F-3). Several of the transducers have anomalous response peaks above the normal bandwidth. Those in Figure F-5 are especially strong, and merit close examination.

Figure F-6 indicates that the phasor measurement unit (PMU) has a bandwidth near 7 Hz. The 30 samples per second rate of the PMU provides a Nyquist frequency of 30/2 = 15 Hz, which is also the frequency for the first null in the response. Unless the secondary response peaks above the first null ("sidelobes") are much lower than shown, the PMU may respond to modulating signals above 15 Hz, and alias them into the normal information band.

At present there is not much direct information on PMU protection against such effects. PMU response has been approximated here by that of the uniform four cycle averaging that is done in its final filtering stage. Earlier filters have the effect of reducing the sidelobes as shown, but they too are potential sources of aliasing [6-14]. These issues will be examined more closely in laboratory tests conducted under the WAMS project [6-9–6-10].